# UPLINK CONTROL INFORMATION SIGNALING IN INTER-SITE DOWNLINK CARRIER AGGREGATION SCENARIOS

## FIELD

**[0001]** The present invention relates to uplink control information signaling in inter-site downlink carrier aggregation scenarios. More specifically, the present invention exemplarily relates to measures (including methods, apparatuses and computer program products) for realizing uplink control information signaling in one of possible inter-site downlink carrier aggregation scenarios.

## BACKGROUND

**[0002]** The present specification generally relates to transmission of control data from a terminal to base stations in network deployments providing inter-site downlink carrier aggregation.

**[0003]** Inter-site downlink carrier aggregation (CA) means aggregation of a primary carrier and at least one secondary carrier, wherein the carriers are provided by base stations on different sites. Inter-site CA with non-fiber based connection between the transmission nodes, i.e. the involved base stations (e.g. evolved NodeB, eNB) is a considered concept for Rel-12/Rel-13 of the 3$^{rd}$ Generation Partnership Project (3GPP) Evolved Universal Terrestrial Radio Access (E-UTRA) specifications, i.e. for Long Term Evolution (LTE) Rel-12/Rel-13 specifications. The main use case for inter-site CA is considered to be in heterogeneous network deployments, i.e. HetNet deployments, with dedicated carrier at pico layer. In such network deployments, inter-site CA represents a cost efficient solution enabling low cost/capacity transport for pico cells and offloading for macro cell with no service degradation to terminals like user equipments (UE). Actually, UEs might even experience performance increase in terms of increased downlink throughput and improved mobility robustness with rapidly varying radio conditions (due to make-before-break and/or early handover to small cells).

**[0004]** Due to the assumption of a high latency/low capacity connection between the transmission nodes, inter-site CA implies distributed Layer **1** (L**1**)/Layer **2** (L**2**) radio resource management (RRM). That means that functionalities such as channel-aware scheduling, fast adaptive modulation and coding (AMC) and L**1** hybrid automatic repeat request (HARQ) have to be performed separately at the macro eNB and the pico eNBs.

**[0005]** As a consequence, uplink control information (UCI) transmitted from the UE to assist fast L**1**/L**2** RRM in principle needs to be separately signaled to the macro eNB and the pico eNB. Currently with Rel-10 specification, UCI is by default transmitted on the primary cell (PCell). That is, assuming that with inter-site CA the component carrier used at macro eNB is configured as PCell, UCI information (including channel quality indicator (CQI) and HARQ acknowledgment/negative acknowledgement (A/N) for the secondary cell (SCell) provided by the pico eNB) is only available at the macro eNB.

**[0006]** Several solutions considering physical uplink control channel (PUCCH) configuration on SCell have been proposed, wherein dual-carrier transmission capable terminals as well as single-carrier transmission capable terminals are considered. However, all the proposed solutions require changes to the 3GPP specifications and a new UE category, which is expectable earliest in LTE Rel-12. This might mean that the inter-site CA concept with high latency low capacity connection between eNBs will in practice be usable by operators first around 2018-2019.

**[0007]** Hence, the problem arises that an implementation of the inter-site CA concept, in particular of the transmission of UCI control information to each of the involved base stations require drastic changes to the 3GPP specifications which are not able to be assembled in either LTE Rel-10 or Rel-11 specifications.

**[0008]** Hence, there is a need to provide for uplink control information signaling in inter-site downlink carrier aggregation scenarios, in particular for LTE Rel-10 and onwards network deployments.

## SUMMARY

**[0009]** Various exemplary embodiments of the present invention aim at addressing at least part of the above issues and/or problems and drawbacks.

**[0010]** Various aspects of exemplary embodiments of the present invention are set out in the appended claims.

**[0011]** According to an exemplary aspect of the present invention, there is provided a method of a device providing primary cell functionality for communication in inter-site carrier aggregation mode aggregating a primary carrier and at least one secondary carrier, comprising transmitting a downlink transmission, said downlink transmission being used as a timing reference, receiving an uplink transmission comprising at least a time difference, calculating a first receiving timing based on an estimated second receiving timing at said device, said time difference and a predetermined timing advance value, and transmitting a first inter-site control transmission comprising at least a difference between said calculated first receiving timing and a timing of said transmitting said downlink transmission.

**[0012]** According to an exemplary aspect of the present invention, there is provided a method of a device providing secondary cell functionality for communication in inter-site carrier aggregation mode aggregating a primary carrier and at least one secondary carrier, comprising obtaining uplink transmission resources for an uplink control information transmission on said primary carrier, deriving a receiving timing for said uplink control information transmission, detecting said uplink control information transmission on said primary carrier based on said uplink transmission resources and said receiving timing, and decoding uplink control information from said uplink control information transmission.

**[0013]** According to an exemplary aspect of the present invention, there is provided an apparatus providing primary cell functionality for communication in inter-site carrier aggregation mode aggregating a primary carrier and at least one secondary carrier, said apparatus comprising a connection controller configured to transmit a downlink transmission, said downlink transmission being used as a timing reference, and to receive an uplink transmission comprising at least a time difference, and a control module configured to calculate a first receiving timing based on an estimated second receiving timing at said device, said time difference and a predetermined timing advance value, wherein said connection controller is further configured to transmit a first inter-site control transmission comprising at least a difference between said calculated first receiving timing and a timing of said transmitting said downlink transmission.